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THE DRYING CHARACTERISTICS AND QUALITY EVALUATION OF TRAY DRIED CUSTARD APPLE (*ANNONA SQUAMOSA* L.) PULP

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ABSTRACT

A small tree named Annona Squamosa belonging to the Family Annonaceae of the order Magnoliales produces a fruit know as custard apple. The genus name, 'Annona' is from the Latin word 'anon', which means 'yearly produce'. The custard apple (Annona Squamosa L.) is one of the important dry land fruit grown in arid land all over the country. The study was undertaken to investigate drying characteristics of custard apple pulp in tray dryer at different temperatures 45,50,60 and 70°C respectively, Physicochemical properties of custard apple powder such as moisture percentage, titrable acidity, total sugar content, total phenolic content, Flavonoid content, nutritional composition, non-nutritional qualities were studied. The average drying time required to attain the average moisture content of 4% drying temperature of 45, 50, 60, and 70°Cwere 2990, 2880, 2400, 1980 minutes, respectively. Thickness of pulp layered on the tray was 4 mm. The samples were also evaluated for variation in vitamin C and colour. The temperature treatment of 60°C can be considered as the limiting temperature for drying of custard apple pulp to observe minimum reasonable change in colour and ascorbic acid content (220mg/100g) compared to 70°C which was 150mg/100g. Loss of vitamins was also more with increase in temperature. Pulp dried at 60°C was lighter in colour and L*value decreased with an increase in temperature indicating the darkening of the powder.

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Original Article

INTRODUCTION

The custard apple scientific name is *Annona Squamosa*, and it's basically from the family of Annonaceae. Out of different nutritious and delicious fruits present custard apple is one of them. Being a Subtropical fruit tree, the tree is erect the branches are low and to some extent shrubby, height ranges from 5 to 9m. The leaves are having closely associated hairy petioles and are deciduous, alternate, 2-ranked. Among the species of Annona Custard apple is the utmost extensively cultivated of altogether, all over the tropics and warmer subtropics such as Australia, Indonesia, Thailand, Taiwan, Brazil, southern Florida, India, West Indies, it is grown extensively. It became -familiarized to southern Asia before 1590 (Dhamsaniya, 2012). Generally eaten as a dessert fruit and has enormous applications in the preparations of beverages and ice creams. Processed products such as jam, jelly, crush etc. prepared from custard apple has additional demand in the market if they have flakes and pulp (Kad *et al.*, 2016). Custard apple being a hardy crop, can be grown on marginal lands with least contributions. Custard apple, commonly known as Sitaphal is grown in nearly40000 ha in India chiefly in the states of Andhra Pradesh, Assam, Tamil Nadu and cultivated wild in Deccan plateau and some parts of central India (Sravanthi *et al.*, 2014). Many of dryland fruits still needs to be exploited to its extreme degree the custard apple (Annona Squamosa L.) with 20,497 MT production from 4,990 ha of area in Maharashtra is one of them. The maximum produce is exported in bulk from India to UAE, Saudi Arabia, Bangladesh and Kuwait (Kamble and

Soni, 2010). Bark of sugar apple is proved to contain phytochemical compounds such as alkaloid, tannin, protein, saponin, phenolic compound etc. which are believed to have antioxidant activity that scavenges free radical and is significant from the perspective of pharmacology (Kadarani *et al.*, 2015).

Drying basically is the moisture removal process of resulting cause of synchronized heat and mass transfer. The main intent for which it is carried out is the reduction of water up to a level at which spoilage due to microbes and deterioration reactions is greatly minimized (Kabiru *et al.*, 2013). Fruits and vegetables drying is attained through numerous methods, tray drying is one of them. Drying has countless probabilities in processed food industries as being conceivably the oldest, most common and most assorted of chemical engineering and process for preservation of food. Though, the process of drying is an energy intensive as it usually requires hot air as heating medium to permit real-time heat and mass transfer between the drying air and material being dried out, furthermore eminence of food degrades through drying. (Aerogels, 1994). Furthermore to preservation, drying depresses the price of packaging, storage and transportation by reduction in both, the weight and volume of the final product (Shete *et al.*, 2015).

The food to be dried is spread in thin layers in tray dryers, on steel trays where drying occurs. Heat generation might be due to air current sweeping across the trays, orby conduction from heat trays or heated shelves on which the trays lie, or through radiation from heated surfaces. Mostly tray dryers are heated by blowing hot air(Saxena and Dash, 2015).

The Custard apple is a seasonal fruit and its availability throughout the year is low also it being a very delicate fruit in its post-harvest losses are high about 13-25% (Sashi *et al.*, 2016). It is slightly grainy, a bit slippery, very sweet and very soft. Therefore, an attempt was made in this study to prepare tray dried custard apple powder that can be utilized for industrial and various purposes.

METHODS AND MATERIALS

Raw Materials

Fresh, well matured Custard apple was procured from the local market of Varanasi. After washing and sorting and peeling custard apples were cut into two halves and scooping of pulp was done manually. After that it was passed through pulper for removing of seeds from the pulp. The prepared pulp was passed through muslin cloth to remove the grittiness in pulp. The pulp was spread on the stainless-steel trays and the thickness of the pulp was 4 mm. The model and make of the tray drier waskhera instruments KI 183 industrial type with forced air circulation. The walls of the dryer were insulated to minimize heat loss. Products were loaded on the dryer's perforated drying tray 60 cm × 60 cm

Experimental Plan

Experimental plan is shown in the Table 1

Table 1: Treatment Combination

Temperatures	Treatments
45	T0
50	T1
60	T2
70	T3

MOISTURE CONTENT

Determination of Moisture

For estimation of moisture, a standard procedure **(I.S. 5162, 1969)** was followed.

$$Moisture\ content\ \% = Intial\ weight - Weight\ of\ dry\ matter/intial\ \ weight\ \times 100$$

Titrable Acidity

The acidity of the samples will determined by diluting an aliquot of the sample with distilled water and titrating with0.1N NaoH using phenolphthalein as indicator. The calculated acidity was expressed as percent anhydrous citric acid.

$$Titrable\ Acidity\ = Burett\ Reading\ \times\ 0.1 \times\ 0.0064\ \times 100/sample\ weight$$

TSS

The TSS of Custard apple powder was measured by standard procedure suggested by Ranganna (2009). TSS content was determined by Digital Refractometer**.**

pH

The pH of Custard apple powder was measured by standard procedure (Ranganna, 2009). It was determined by pH meter.

Ascorbic Acid (mg/100ml or 100g Sample)

Ascorbic acid was estimated by visual titration method (Ranganna, 1986).

Colour

The colour of custard apple powder was measured using Miniscan EZ4500L model HunterLab colorimeter. In the Hunter's lab the colour of a sample is denoted by the three dimensions, L*, a* and b*. The L*, a* and b*readings were then recorded. The L* value gives a measure of the lightness of the product colour from 100 for perfect white to 0 for black, as the eye would evaluate it. The redness/greenness and yellowness/blueness are denoted by the a* and b* values, respectively. The colour of the samples was measured after putting the samples in front of smallest aperture.

Estimation of Protein

Estimation of protein was done by kjeldahl method (Ranganna, 1986).

Determination of Ash

Ash content was determined as per method recommended by **Ranganna 2001** in Bulletin No. 70.

$$\text{Ash } (\%) = \frac{W2-W1}{W} \times 100$$

W = Weight of sample

W_1 = Weight of silica dish

W_2 = Weight of silica dish + Ash.

Extraction

Extraction was performed according to a method by (Vasco *et al.*, 2008), which was modified. Two grams of dried custard apple were extracted twice at room temperature under continuous stirring for 1 h with 20 mL methanol: water (50:50 v/v) mixture and then intermittent centrifugation (4000 rpm, 15 min, 5 °C) was done and supernatants were collected the mixture was then worked up as described above and analyzed to quantify antioxidant activity, flavonoid content and total phenolic content.

Determination of Antioxidants by DPPH Test

DPPH Scavenging Activity Assay

Antioxidant Activity

The free radical scavenging activity of the samples was determined by the2, 2-diphenyl-1-picrylhydrazyl (DPPH) method (Turkmen *et al.*, 2005) with some modifications. Different extract dilutions were in triplicate. An aliquot of 2 mL of 0.15 mMDPPH radical in methanol was added to a test tube with 1mL of the sample extract. The reaction mixture was mixed in a vortex for 30 s and left to stand at room temperature in the dark for 20 min. Absorbance was measured at 517nm with a spectrophotometer.

Flavonoid Content Determination

Total flavonoids were measured by a colorimetric assay. A0.5 mL aliquot of custard apple powder extract solution was added to a 5 mL volumetric flask containing 2 mL distilled water. At time zero, 0.15 mL NaNO2 aqueous solution (5 g 100mL-1) was added to the flask. After 5 min, 0.15 mL AlCl3aqueous solution (10 g 100 mL-1) was added. At 6 min, 1mL 1 M NaOH was added to the mixture. The reaction flask was immediately diluted to volume by adding 1.2mL distilled water and thoroughly mixed. Absorbance of the mixture was determined at 415 nm as compared to the prepared water blank. Total extract flavonoids were expressed as mg quercetin equivalents 100 g-1 dry weight.

Determination of Total phenolic Content

Total phenolic content Total phenolic content (TPC) was determined by the colorimetric method with Folin-Ciocalteu reagent (FC) according to(Chuah *et al.*, 2008) with modifications. A 0.5 mL aliquot of fruit extract solution was transferred to a glass tube to which 0.5 mL of reactive FC was added after 5 min, and 2 mL Na2CO3 solution (200 mg mL-1) added and shaken. The sample was then mixed in a vortex mixer and the reaction continued for 15 min at room temperature. Afterward, 10 mL of ultrapure water was added and the formed precipitate removed by centrifugation for 5 min at 4000 rpm. Finally, absorbance was measured with a spectrophotometer, at 725 nm and compared to a gallic acid (GA) calibration curve. Results were expressed as mg GA/g. All measurements were triplicated.

Crude Fibre Analysis

The method suggested by Ranganna (2001) was employed to determine the fibre content of the custard apple powder. 2 g of powder was taken and approximately 0.5 g of asbestos, to the digestion flask. Added 200 ml of concentrated sulphuric acid solution immediately connected the digestion flask with a condenser, and heated. During digestion care should be taken to keep the material from remaining on the side of the digestion flask without connecting with the solution. After 30 min removed the flask and filtered through linen in a fluted funnel, washed with boiling water until the washings were no longer acid. Heated sodium hydroxide under reflux condenser, washed the residue in acid digestion back in to the

flask with 200 ml of boiling sodium hydroxide solution. Connected the flask with a reflux condenser and boiled for exactly 30 min.

Total Sugar

Invert sugar reduces the copper in fehling's solution to red, insoluble cuprous oxide. The sugar content in food sample was estimated by determining the unknown sugar solution required to completely reduce a measured volume of fehling's solution. Total sugar was estimated by Lane and Eynon method suggested by Ranganna (2001).

Statistical Analysis

Statistical analysis was done by RBD analysis Software The results obtained on the design of the sensorial acceptability were analyzed statistically using Analysis of Variance (ANOVA) at the 5% level of significance, to compare the mean.

RESULTS AND DISCUSSIONS

Table 2: Results of the Physicochemical Analysis of Dried Custard Apple Samples

Drying Conditions/ Treatments	Moisture %	Ash%	Protein %	Crude Fibre%	Acid Insoluble Ash%	Total Sugars%	TSS%	Titrable Acidity	pH
45	6.47±0.17*	3.50±0.14*	0.26±0.18*	6.68±0.16^{NS}	3.32±0.02*	19.47±0.24*	17.80±0.26*	1.29±0.02*	6.87±0.36*
50	5.66±0.17*	3.67±0.14*	0.31±0.18*	6.36±0.16^{NS}	3.39±0.02*	19.46±0.24*	18.33±0.26*	1.53±0.02*	6.26±0.36*
60	5.39±0.17*	3.58±0.14*	0.39±0.18*	6.12±0.16^{NS}	3.42±0.02*	19.39±0.24*	19.37±0.26*	1.97±0.02*	5.92±0.36*
70	4.52±0.17*	3.13±0.14*	0.49±0.18*	6.03±0.16^{NS}	3.36±0.02*	18.72±0.24*	20.87±0.26*	2.43±0.02*	5.31±0.36*

1Data are expressed as means ± SD of at least two duplicate experiments. Mean ±S.D at p<0.05 significance
***Significant at p<0.05 significance
^{NS} Non significant at p<0.05 significance

Effects of Drying Temperatures on Moisture Content

The moisture content of tray dried custard apple powder was 6.47,5.66, 5.39 and 4.52 respectively as shown in Table 2 there was a decrease in the moisture content as the temperature was increased which was similar to previous results by (Barroca *et al.*, 2013) on pears. During the drying process, moisture loss occurs due to the difference in water vapor pressure between the product and the air surrounding it. Drying time to reach a similar moisture content decreased as the temperature process increased. The average drying time required to attain the average moisture content of 4% drying temperature of 45, 50, 60, and 70°C were 2990, 2880, 2400 and 1980 minutes, respectively. The moisture content of a product decides its shelf life the moisture content is in the range of 5-6.5%which makes it stable for storage.

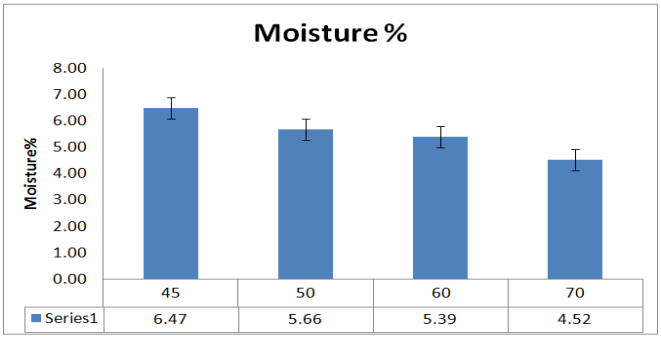

Figure 1: Moisture Percentage of Custard Apple Pulp at Different Drying Temperatures

Effects of Drying Temperatures on Ash Content

The ash content of tray dried custard apple powder was3.50, 3.67, 3.58 and 3.13 % showed in Table 2 for 45, 50, 60 and 70 °C respectively shown in Figure 2. The ash content of a food product refers to the inorganic residue remaining from the burning of organic matter. The ash content refers to the mineral content of the pulp There was a significant decrease in the ash content as the temperature was increased which was similar to (Gani and Kumar, 2013) in which there was a significant decrease in the ash content in different osmotic dehydration and (Reis *et al.*, 2013) on Cumari Peppers From Pará which may have resulted from the temperatures applied, which degrade the micronutrients represented in the analysis of the ashes. There was significant difference between the ash content of dried custard apple powder at different temperatures.

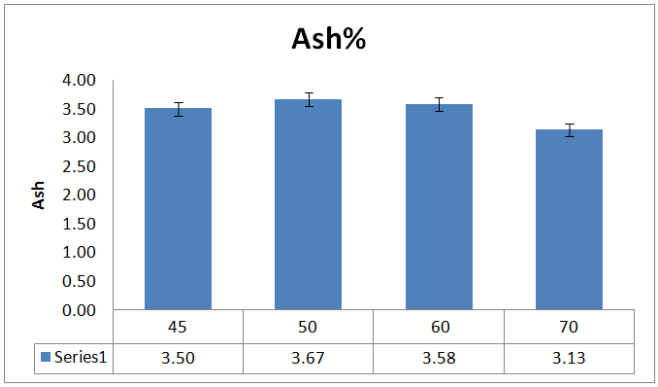

Figure 2: Ash Percentage of Custard Apple Pulp at Different Drying Temperatures

Effects of Drying Temperatures on Titrable Acidity

Titrable acidity of tray dried custard apple powder was shown in Table 2 0.26, 0.31, 0.39, 0.49 (g citric acid/100 g)for 45,50,60 and 70 °C respectively shown in Figure 3. There was a significant increase in the Titrable acidity similar increase was reported by (Swami *et al.*, 2014) in osmo tray dried jackfruit bulbs gradually increased due to acid hydrolysis and rise in acidity is chiefly attributed to the high amount of moisture lost from the samples and decreasing of ph. The determination of acidity can provide important data to evaluate the preservative state of the product, since the processes of decomposition by hydrolysis or oxidation can affect the sensory and nutritional characteristics of the product.

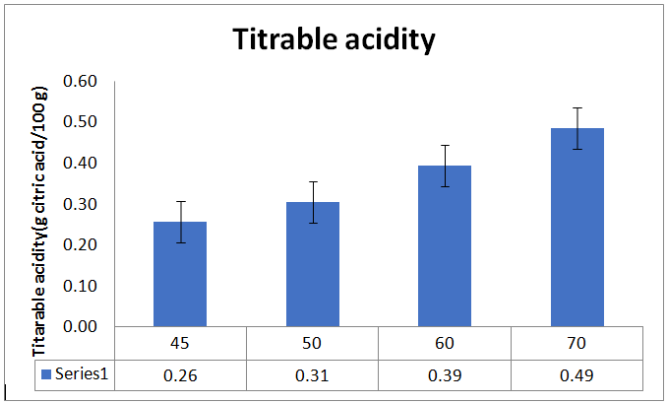

Figure 3: Titrable Acidity Percentage of Custard Apple Pulp at Different Drying Temperatures

Effects of Drying Temperatures on Protein Content

Protein in Custard apple powder was 6.68,6.36,6.12 and 6.03 shown in Table 2 there was a significant loss in the protein percentage of custard apple powder on different temperatures, which may be due to protein denaturation during heating as protein is a heat sensitive component similar was reported by (Quispe-fuentes *et al.*, 2013) on goldenberry however (Reis *et al.*, 2013) reported insignificant difference in protein content in Cumari Peppers from Pará.

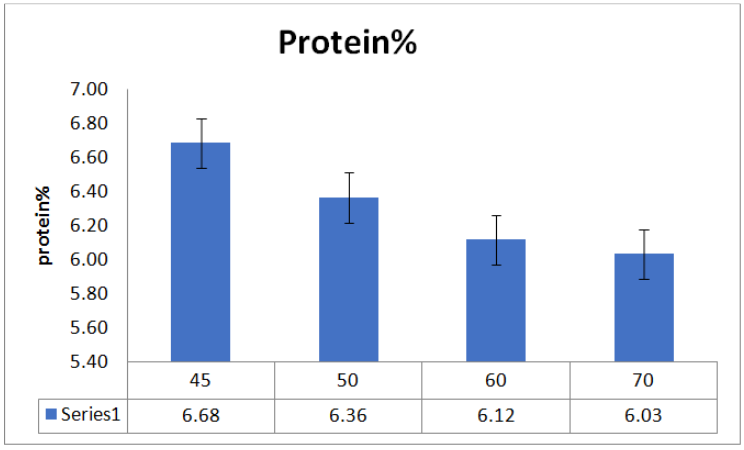

Figure 4: Protein Percentage of Custard Apple Pulp at Different Drying Temperatures

Effects of Drying Temperatures on Crude Fibre

The main constituents of the crude fiber is composed of cellulose and lignin are parts of fruits. The Crude fibre was 3.32, 3.39, 3.42, and 3.36 shown in Figure 5, in tray dried custard apple powder for 45, 50, 60 and 70 °C there was an insignificant difference between the crude fibre content.

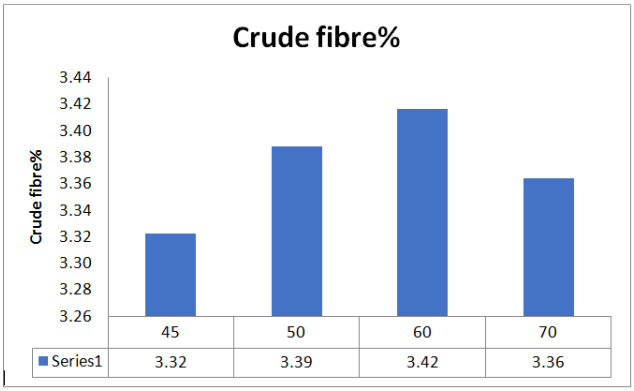

Figure 5: Crude Fibre Percentage of Custard Apple Pulp at Different Drying Temperatures

Effects of Drying Temperatures on pH

The pH values were 6.87,6.26,5.92 and 5.31 shown in Table 2 for 45,50, 60 and 70 °C there was significant difference for pH values which may be due to rise in acidity.

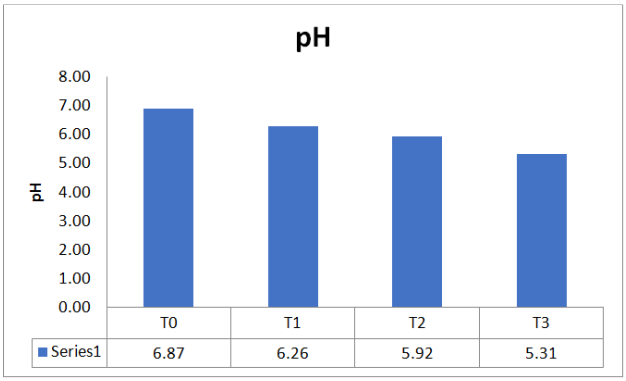

Figure 6: pH of Custard Apple Pulp at Different Drying Temperatures

Effects of Drying Temperatures on Total Soluble Solids

The TSS content 17.80,18.33,19.37 and 20.87 for 45,50, 60 and 70 °C shown in Table 2 there was a significant difference for custard apple powder the rise may be due to increase in total solid content and decrease in moisture content. This was similar to findings by (Yusufe *et al.*, 2017) who reported that the TSS value rise with increment in drying-air temperature but decline beyond 80 °C.

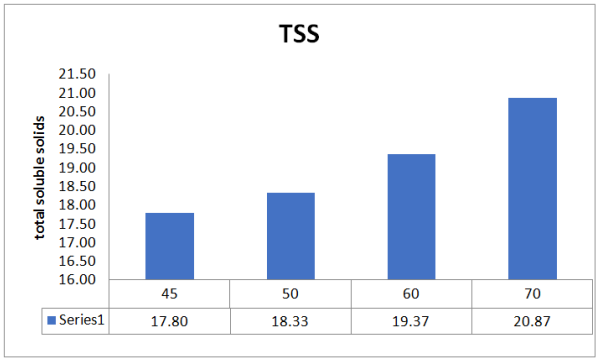

Figure 7: Total Soluble Solids Percentage of Custard Apple Pulp and Different Drying Temperatures

Effects of Drying Temperatures on Acid Insoluble Ash

The acid insoluble ash was found to be 0.56, 0.59, 0.51 and 0.53 shown in Table 2 respectively at 45, 50, 60 and 70 °C temperatures there was a significant rise in acid insoluble ash.

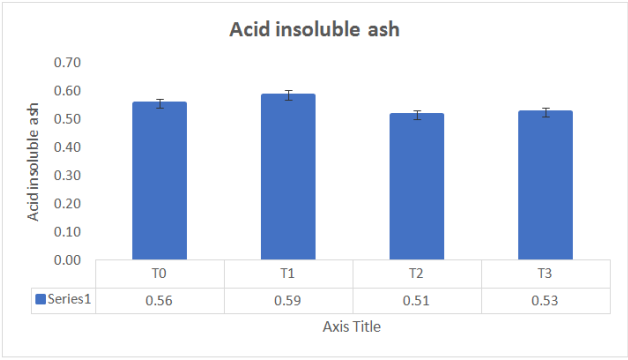

Figure 8: Acid Insoluble Ash Percentage of Custard Apple Pulp and Different Drying Temperatures

Effects of Drying Temperatures on Ascorbic Acid

The ascorbic acid content of the tray dried custard apple powder decreased with increase in temperature which was obvious due heat sensitive nature of ascorbic acid there was a significant loss in the ascorbic acid content and 70°C which shows that the limiting temperature for drying of custard apple pulp is 60°C values of ascorbic acid at 45,50, 60 and 70 °C are 0.14, 0.23, 0.23 and 0.230.14 shown in Table 2.

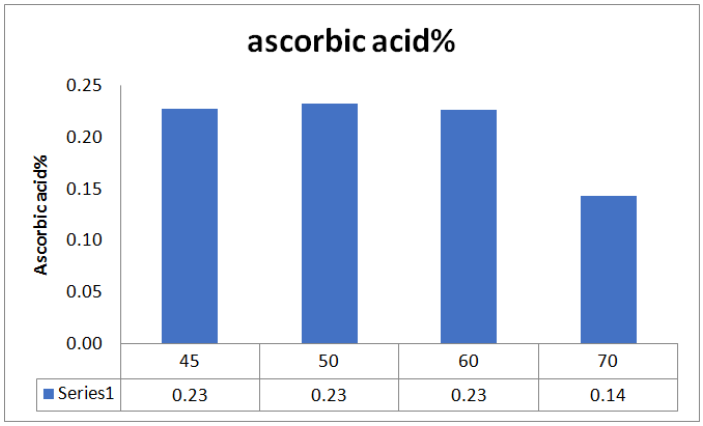

Figure 9: Ascorbic Acid Percentage of Custard Apple Pulp at Different Drying Temperatures

Total phenolic Content

Total phenolic content was 3.88, 3.96, 3.32 and 3.23(mg GA/g) shown in Figure 10 there was a significant decrease in the phenolic content which is due to the use of high temperature during drying similarly use of high temperatures during extraction, pasteurization and storage of food results in loss of phenolic compounds, particularly due to the degradation of anthocyanins. In addition to temperature and light, the content of phenols is also affected by hydrolysis andoxidation reactions.

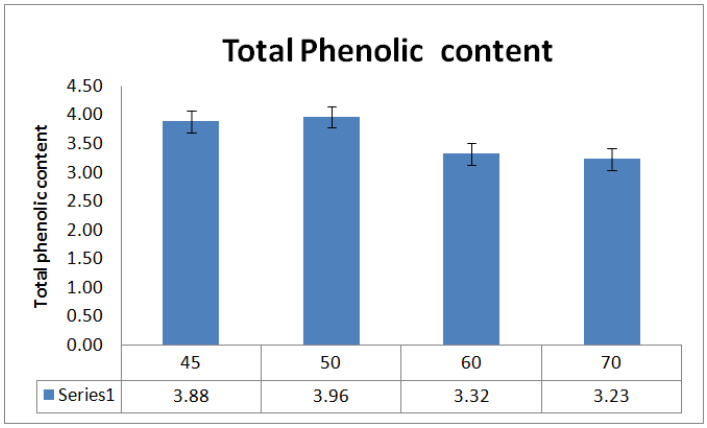

Figure 10: Total phenolic Content of Custard Apple Pulp at Different Drying Temperatures

Total Sugars

There was significant difference between the total sugars of custard apple powder 19.47, 19.4619.39 and 18.72 for 45, 50, 60 and 70 °C temperatures shown in Figure 11 there was loss of total sugar due to long drying time, which may degrade the sugar.

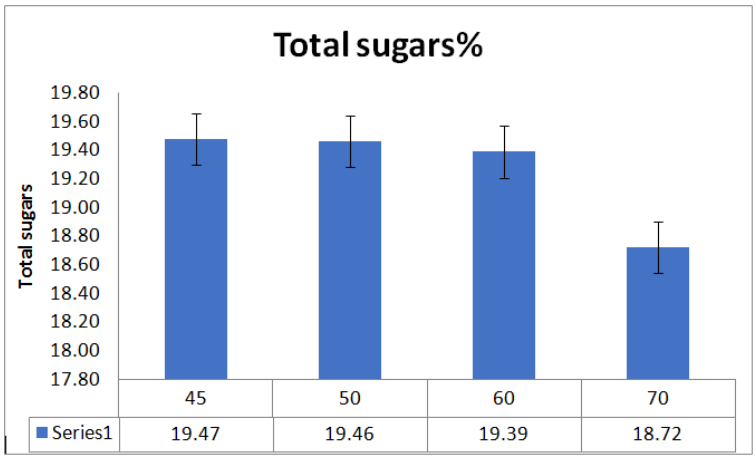

Figure 11: Total Sugars Percentage of Custard Apple Pulp at Different Drying Temperatures

Total Flavonoid Content

There was significant difference between the total flavonoid content 78.60. 75.82, 74.31 and 74.29 expressed as mg quercetin equivalents 100 g-1 dry weight for 45, 50, 60 and 70 °C temperatures respectively. The loss of flavonoid was due to the drying temperature the bioavailability of such compounds are also due to differences in cell wall structures, location of glycosides in cells, and binding of phenolic compounds inside the food matrix, which are straight away related to conditions of fruit drying.

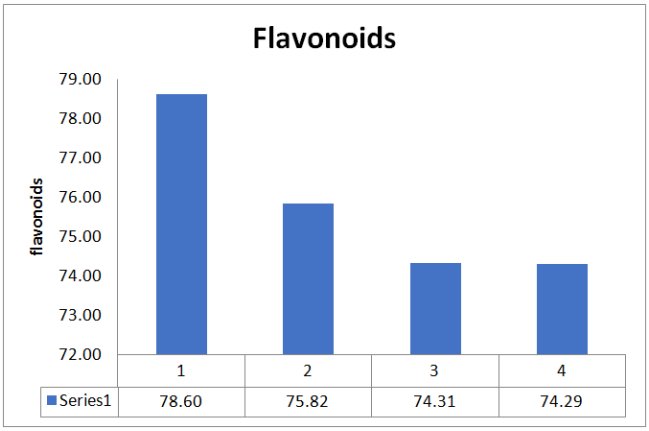

Figure 12: Flavonoid Content of Custard Apple Pulp at Different Drying Temperatures

Antioxidant Activity

Tray dried custard apple powder showed an insignificant difference in antioxidant activity and14. 48, 14.39,14.38 and 14.36% inhibition were the results of 45,50, 60 and 70 °C temperatures shown in Figure 13. However, there was a loss in % inhibition, which may be due to loss of ascorbic acid, which is a natural antioxidant found in foods. Phenolic compounds are linked with imperative functions in plants, including pigmentation and defense, in addition to fruit peels and seeds, and to a lesser extent in pulp, justifying the low DPPH value found for the Custard apple pulp powder also there was a loss due to heating employed.

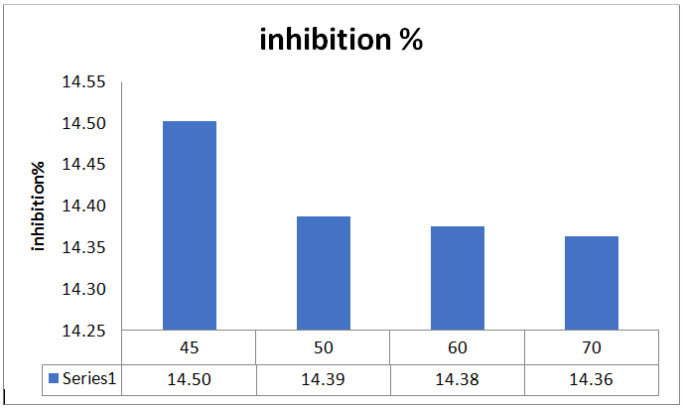

Figure 13: Inhibition % of Custard Apple Pulp at Different Drying Temperatures

Colour

The colour brightness coordinate L* is used to assess the whiteness value of a colour, ranges from black at 0 to white at 100. The chromaticity coordinate a* determines green when negative and red when positive, and the chromaticity coordinate b* measures yellow when positive and blue when negative the results of hunter colour is shown in Table 3 as it can be seen that the L value decreased with the increase in temperature, which shows the darkening of powder on heating this indicates that custard apple should be dried at lower temperatures. This was similar to reports by (İncedayi *et al.*, 2016) on dried apricots in which L value increased with increase in temperature. The browning of the product is due to the Maillard reaction of sugars present in the custard apple pulp.

Table 3: Color

Temperature °C	L	A	B
45	89.44	-1.47	-1.82
50	89.00	-1.38	0.65
60	85.23	0.62	0.72
70	82.32	0.68	0.89

CONCLUSIONS

The present work describes the possibility of drying of Custard apple via tray drier. Hot air-drying at 60°C was adequately effective in preserving colour and nutritive value. Thus, the temperature treatment of 60°C can be considered as the limiting temperature for drying of custard apple pulp to observe minimum reasonable change in colour and ascorbic acid content (220mg/100g) compared to 70°C which was 150mg/100g.

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